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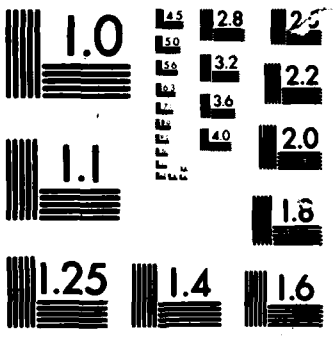

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LABORATORY NOTE NO. 86-56

IMAGE ANALYSIS OF MACULAR LASER LESIONS

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JANUARY 1986

LETTERMAN ARMY INSTITUTE OF RESEARCH
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In conducting the research described in this report, the investigation adhered to the "Guide for the Care and Use of Laboratory Animals," as promulgated by the Committee on Revision of the Guide for Laboratory Animal Facilities and Care, Institute of Laboratory Animal Resources, National Research Council.

This material has been reviewed by Letterman Army Institute of Research and there is no objection to its presentation and/or publication. The opinions or assertions contained herein are the private views of the author(s) and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense. *(AR 360-5)*

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ABSTRACT

Small foveal retinal lesions are often difficult to detect with conventional ophthalmoscopy, as well as the visual functions effects of such damage. In order to improve conventional ophthalmoscopy of such lesions we have adapted computer image analysis techniques to quantify the spatial and temporal characteristics of such lesions. Our methodology incorporates conventional statistical tests of significance for plotting gray scale differences along common retinal landmarks. Preliminary data indicates that punctate retinal lesions in the fovea vary over time somewhat differently than similar size lesions placed parafoveally. Such temporal variations in gray scale distribution may aid in explanation of visual functional affects of such lesions.

Image Analysis of Macular Laser Lesions

Small lesions produced with laser sources in the primate retina are often difficult to detect and may in fact change in opacity, color, or size over time. Such changes often are undetected or under utilized with regard to signals they could provide for laser safety or clinical laser treatment. Many industrial and military lasers are used in field applications; hence, individuals working in such environments could cumulate small punctate lesions in their retina and have little awareness of such damage. Recent animal experiments with small spot foveal exposure have demonstrated the possibility of such occurrences (1,2). In addition, since the laser is becoming a frequently used mode of therapy in ophthalmology and other areas of medicine, more precise characterization of the laser effect on biological tissue, as well as quantification of the response of biological tissue to laser exposure, is desirable for optimal laser treatment with minimal hazards.

In this paper, we will present one approach to quantify the retinal image. Using computer image analysis techniques which characterize gray scale content with respect to retinal area, we will demonstrate how these techniques can be utilized to characterize small retinal lesions and their subsequent change over time with minimum change in routine clinical procedures. No doubt other ophthalmologic techniques involving more complexity could be combined with improved sensitivity.

METHODS

Data from two rhesus monkeys are presented in this paper. Retinal lesions were produced with a single Q-switched ND/YG pulsed dye laser (>600nm) pulse at levels varying from 3 to 10 times the threshold burn level. Retinal photography (Kodak Ektachrome 100 film) immediately before and various times after exposure, was carried out for all sessions and across all animals. The resulting 35-mm slides were rear projected onto a polacoat fine resolution projection screen and digitized with a Robot 650 video frame grabber (256 x256 resolution with 64 shades of gray) and interfaced with a DEC PDP 11/70 minicomputer. Retinal images were then analyzed for gray content at various selected regions on the digitized image. The size of the sampling area, its location on the retina, and the number of samples taken could be varied.

Difference gray scale plots were automatically normalized with respect to a common retinal landmark present in each photograph. The difference plots between any two photographs reflects differences in gray scale distribution along the cursor that are statistically significant ($P > .05$). Absolute differences in contrast that might exist between some photographs are eliminated by this analysis.

RESULTS

In Figure 1, a single fundus photograph of a foveal and a parafoveal lesion taken approximately 1 hr after exposure is shown. Both lesions were made with single Q-switched dye laser exposures. Both lesions are about 50 microns in diameter. The temporal changes in gray scale content for the foveal lesion over this 1-hour period are shown in Figure 2. The distribution of gray shades shifted from a somewhat symmetrical increase in darker gray shades to a more asymmetrical gray scale distribution relative to preexposure gray scale content.

In Figure 3a and b, the foveal lesion gray scale content across the horizontal cursor relative to preexposure gray scale content is shown immediately and 1 hour after exposure. Statistically significant differences between before and immediately after exposure data are not the same as those obtained at 1 hour after exposure. Similarly in Figure 3c and d, immediately and 1 hour after exposure changes in the parafoveal lesion are varied and nearly opposite at the end of 1 hour after exposure. While the foveal lesion becomes asymmetrically darker, the parafoveal lesion becomes uniformly lighter at 1 hour after exposure.

DISCUSSION

Differential comparison of lesions in foveal and parafoveal areas indicates somewhat opposite changes in gray scale content during the initial hour after exposure. Such differences may reflect differences in pigmentary migration as well as repair processes in these areas. It is well known that macular pigment (xanthrochrome) as well as pigment epithelium (melanin) are affected in suprathreshold laser lesion processes and the differences may be due to changes occurring in the macular pigment, although the major absorption for the macula pigment occurs in the short wavelength region. The wavelength used in these exposure was > 600 nm, which is relatively transparent to macular pigment. Differential retinal thickness between the fovea and parafoveal areas and blood supply are other possible explanations of this observation.

Perhaps, more importantly, quantification of these changes dramatically reflects the lack of correlation between small spot induced foveal lesions and measured functional loss in non-human primates. Such lesions correlate poorly with permanent change in visual function (1,2). The possibility that changes in gray scale content may reflect differential involvement of retinal receptor systems and neural spatial processing networks is presently being explored.

We have demonstrated that quantification of gray scale changes can characterize observable changes in laser induced retinal lesions.

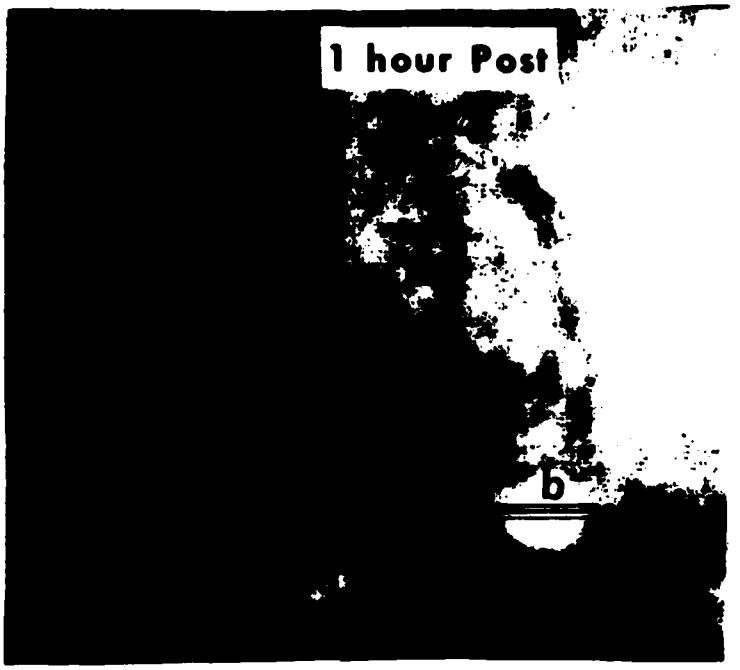

Figure 1. Foveal (a) and parafoveal (b) lesions at 1 hour after exposure.

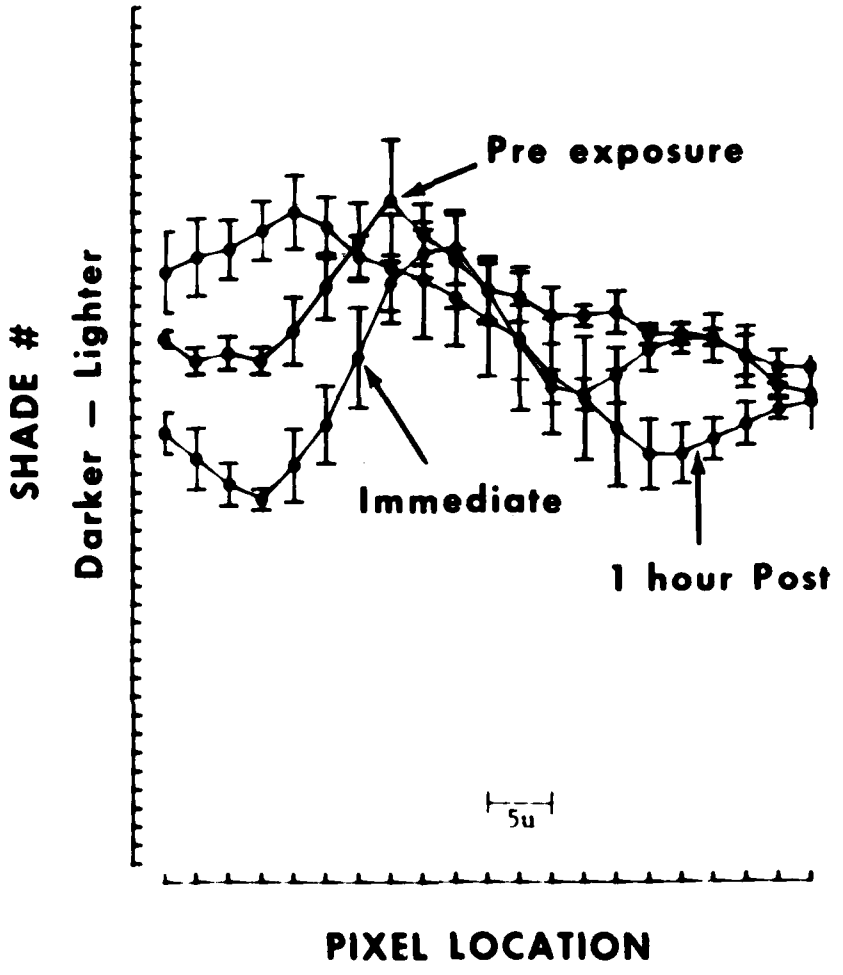

Figure 2. Gray scale foveal distribution before (pre), immediately after exposure, and 1 hour after (post) exposure.

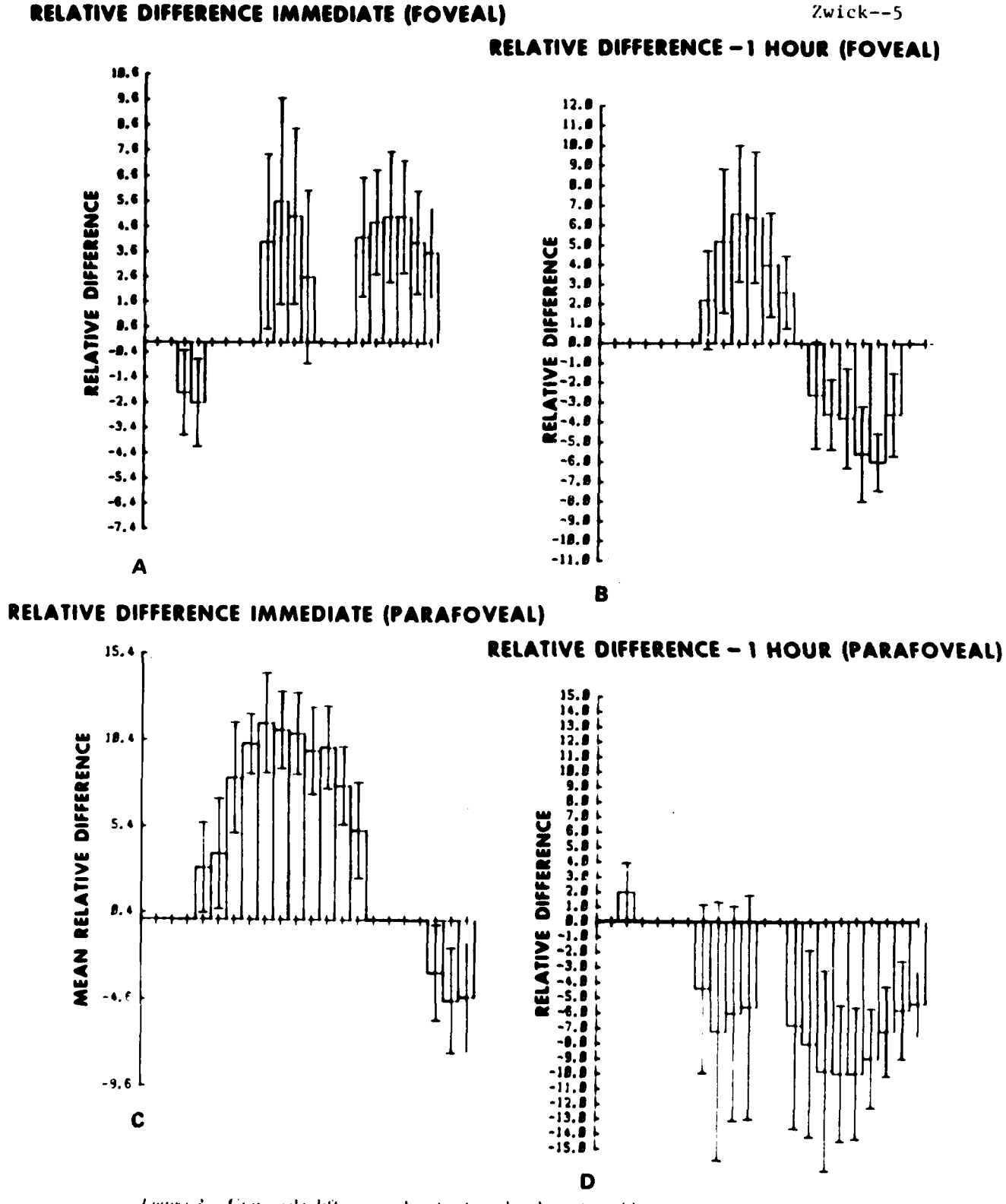

Figure 5. Gray scale difference plots for foveal and parafoveal lesions immediately after and 1 hour after (post) exposure relative to before (pre) exposure gray scale distribution.

These procedures can easily be adapted to standard clinical ophthalmoscopy. Our findings indicate that significant changes in gray scale content of immediate and longer term lesions can be obtained with relatively simple equipment and no increase in patient stress necessary with other procedures for making funduscopy more sensitive. Quantification of the tissue response produced by laser photocoagulation with respect to gray scale criteria may provide useful information to the surgeon. Presently surgeons are limited to all or none opacity criteria as a diagnostic tool for differentiating laser induced lesions from retinal disease lesions. Differentiating such conditions with both the objective criteria described here as well as clinical subjective criteria may improve the differential diagnosis of such retinal lesions.

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2. Zwick H. Visual function changes after laser exposure. a review. Presidio of San Francisco, San Francisco, CA: Letterman Army Institute of Research, 1984; Laboratory Note No. 84-48.

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1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* Image Analysis of Macula Laser Lesions		5. TYPE OF REPORT & PERIOD COVERED Interim Report Apr 85 - Dec 85
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR*(s)* Harry Zwick, Ph.D., Larry Sherman, BS David J. Lund, BS		8. CONTRACT OR GRANT NUMBER*(s)*
9. PERFORMING ORGANIZATION NAME AND ADDRESS Letterman Army Institute of Research Presidio of San Francisco, CA 94129-6800		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Project No. 3M161102BS10CF Work Unit 245: Physiologic Basis of Laser Effects
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Medical Research and Development Command, Ft Detrick, Frederick, MD 21701-5012		12. REPORT DATE January 1986
		13. NUMBER OF PAGES 8
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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Image Analysis; Fovea/macula; Punctate Lesions; Grey Scale Analysis; Animal; Q-switch LASER; Minimal Spot.

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

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